

# CLAIMS

1. A method for use in hierarchical modulation, the method comprising:  
hierarchically modulating at least a first signal and a second signal to provide a  
5 hierarchical modulation signal; and  
transmitting the hierarchical modulation signal;  
wherein the hierarchical modulation signal comprises a sequence of symbols selected  
from a radial-type constellation of symbols.

2. The method of claim 1, wherein the transmitting step includes the step of up-  
converting the hierarchical modulation signal to a radio frequency for transmission.

3. The method of claim 1, wherein the radial-type constellation of symbols comprises  
a number of symbols arranged in a signal space comprising four quadrants, wherein the  
15 symbols in a quadrant are arranged such that for every symbol lying on a circumference of a  
circle at least one other symbol lies on a radial of the circle such that the radial also intersects  
the symbol on the circumference.

4. The method of claim 3, wherein the hierarchically modulating step includes the step  
20 of adjusting a separation distance,  $D$ , between a circumference symbol and a radial symbol.

5. The method of claim 1, wherein the radial-type constellation of symbols comprises  
a number of symbols arranged in a signal space comprising four quadrants, wherein the  
symbols in a quadrant are arranged such that for every symbol lying on a circumference of a  
25 circle at least one other symbol lies substantially on a radial of the circle such that the radial  
also intersects the symbol on the circumference.

6. The method of claim 5, wherein the hierarchically modulating step includes the step  
of adjusting a separation distance,  $D$ , between a circumference symbol and a radial symbol.

7. A method for use in hierarchical modulation, the method comprising:

using a quadrature phase shift keying (QPSK) symbol constellation for an upper layer signal;

using a binary phase shift keying (BPSK) symbol constellation for a lower layer signal; and

5 hierarchically modulating the upper layer signal and the lower layer signal for providing a sequence of symbols for transmission;

wherein, the hierarchically modulating step combines the QPSK symbol constellation and the BPSK symbol constellation such that the sequence of symbols are selected from a radial-type QPSK-BPSK constellation of symbols.

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8. A method for use in hierarchical modulation, the method comprising:

encoding an upper layer (UL) signal to provide an encoded UL signal;

encoding a lower layer (LL) signal to provide an encoded LL signal; and

mapping the encoded UL signal and the encoded LL signal to a radial-type symbol

15 constellation to provide a sequence of symbols for transmission;

wherein the radial-type constellation of symbols comprises a number of symbols arranged in a signal space comprising four quadrants, wherein the symbols in a quadrant are arranged such that for every symbol lying on a circumference of a circle at least one other symbol lies on a radial of the circle such that the radial also intersects the symbol on the

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circumference.

9. A method for use in hierarchical modulation, the method comprising:

encoding an upper layer (UL) signal to provide an encoded UL signal;

encoding a lower layer (LL) signal to provide an encoded LL signal; and

25 mapping the encoded UL signal and the encoded LL signal to a radial-type symbol constellation to provide a sequence of symbols for transmission;

wherein the radial-type constellation of symbols comprises a number of symbols arranged in a signal space comprising four quadrants, wherein the symbols in a quadrant are arranged such that for every symbol lying on a circumference of a circle at least one other symbol lies substantially on a radial of the circle such that the radial also intersects the symbol on the circumference.

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10. Apparatus for use in hierarchical modulation, the apparatus comprising:

a hierarchical modulator for modulating at least a first signal and a second signal to provide a hierarchical modulation signal;

wherein the hierarchical modulation signal comprises a sequence of symbols selected from a radial-type constellation of symbols.

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11. The apparatus of claim 10, further comprising an up-converter for transmitting the hierarchical modulation signal.

12. The apparatus of claim 10, wherein the radial-type constellation of symbols comprises a number of symbols arranged in a signal space comprising four quadrants, wherein the symbols in a quadrant are arranged such that for every symbol lying on a circumference of a circle at least one other symbol lies on a radial of the circle such that the radial also intersects the symbol on the circumference.

13. The apparatus of claim 12, wherein the hierarchical modulator adjusts a separation distance,  $D$ , between a circumference symbol and a radial symbol.

14. The apparatus of claim 10, wherein the radial-type constellation of symbols comprises a number of symbols arranged in a signal space comprising four quadrants, wherein the symbols in a quadrant are arranged such that for every symbol lying on a circumference of a circle at least one other symbol lies substantially on a radial of the circle such that the radial also intersects the symbol on the circumference.

15. The apparatus of claim 14, wherein the hierarchical modulator adjusts a separation distance,  $D$ , between a circumference symbol and a radial symbol.

16. Apparatus for use in hierarchical modulation, the apparatus comprising:

an upper level (UL) encoder for providing a UL encoded signal;

a lower level (LL) encoder for providing a LL encoded signal; and

a hierarchical modulator responsive to the UL encoded signal and the LL encoded signal for providing a sequence of symbols for transmission;

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wherein the hierarchical modulator selects the symbols from a radial-type signal constellation that is a combination of a quadrature phase shift keying (QPSK) symbol constellation and a binary phase shift keying (BPSK) symbol constellation.

5           17. Apparatus for use in a receiver, the apparatus comprising:  
             a down-converter for providing a received signal; and  
             a hierarchical demodulator that processes the received signal by using a radial-type  
             constellation of symbols for recovery of upper layer (UL) data and lower layer (LL) data.

10           18. The apparatus of claim 17, wherein the radial-type constellation of symbols is a  
             combination of a quadrature phase shift keying (QPSK) symbol constellation and a binary  
             phase shift keying (BPSK) symbol constellation.

15           19. The apparatus of claim 17, wherein the radial-type constellation of symbols  
             comprises a number of symbols arranged in a signal space comprising four quadrants, wherein  
             the symbols in a quadrant are arranged such that for every symbol lying on a circumference of  
             a circle at least one other symbol lies on a radial of the circle such that the radial also  
             intersects the symbol on the circumference.

20           20. The apparatus of claim 17, wherein the radial-type constellation of symbols  
             comprises a number of symbols arranged in a signal space comprising four quadrants, wherein  
             the symbols in a quadrant are arranged such that for every symbol lying on a circumference of  
             a circle at least one other symbol lies substantially on a radial of the circle such that the radial  
             also intersects the symbol on the circumference.

25           21. Apparatus for use in a receiver, the apparatus comprising:  
             a down-converter for providing a received signal; and  
             a hierarchical demodulator for processing the received signal for recovering upper  
             layer (UL) data and lower layer (LL) data;

30           wherein the received signal represents a sequence of symbols selected from a radial-  
             type constellation of symbols.

22. The apparatus of claim 21, wherein the radial-type constellation of symbols comprises a number of symbols arranged in a signal space comprising four quadrants, wherein the symbols in a quadrant are arranged such that for every symbol lying on a circumference of a circle at least one other symbol lies on a radial of the circle such that the radial also intersects the symbol on the circumference.

23. The apparatus of claim 21, wherein the radial-type constellation of symbols comprises a number of symbols arranged in a signal space comprising four quadrants, wherein the symbols in a quadrant are arranged such that for every symbol lying on a circumference of a circle at least one other symbol lies substantially on a radial of the circle such that the radial also intersects the symbol on the circumference.

24. A program storage device readable by machine, tangibly embodying a program of instructions executable by the machine to perform method steps for hierarchical modulation, the steps comprising:

using a quadrature phase shift keying (QPSK) symbol constellation for an upper layer signal;

using a binary phase shift keying (BPSK) symbol constellation for a lower layer signal; and

hierarchically modulating the upper layer signal and the lower layer signal for providing a sequence of symbols for transmission;

wherein, the hierarchically modulating step combines the QPSK symbol constellation and the BPSK symbol constellation such that the sequence of symbols are selected from a radial-type QPSK-BPSK constellation of symbols.